

NASA SBIR/STTR Technologies

A3.01-9708 - Nonlinear Parameter-Varying AeroServoElastic Reduced Order Model for Aerostructural Sensing and Control

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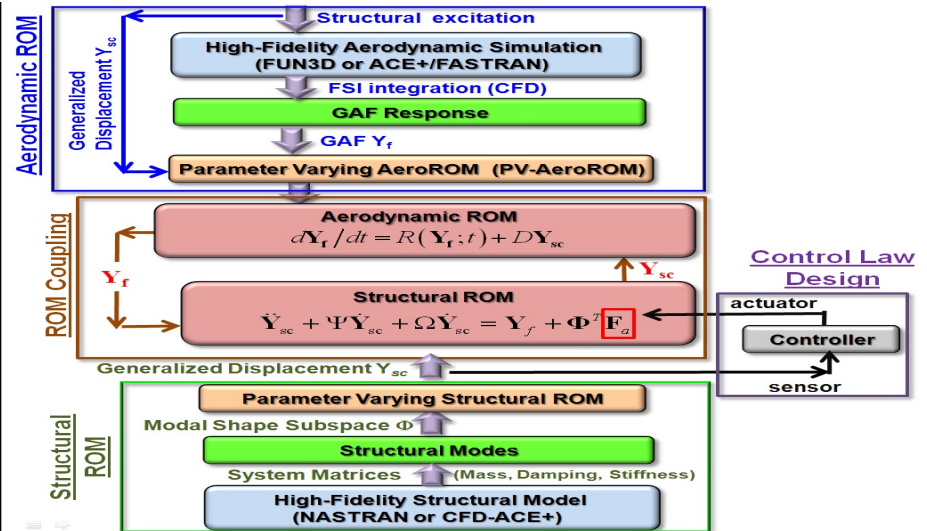
Identification and Significance of Innovation

Active structure control methodologies are broadly utilized to suppress the instabilities caused by LCO, buffet, and gust load. The capability to accurately analyze aeroelasticity in conjunction with control law design is essential for developing high-performance, safe, aerospace vehicles. The existing aeroelastic analysis techniques are ill-suited for aeroservoelasticity (ASE) due to several inherent limitations including prohibitive computational cost. We propose to develop rigorous reduced order model (ROM) algorithms and software to automatically generate nonlinear, parameter-varying ASE ROM. Key innovations include (1) incorporation of aerostructural sensing and control for integrated simulation; (2) hybrid methodologies to simultaneously tackle nonlinear aerodynamics and enable parameter-varying ROMs in all flight regimes for real-time flight control analysis; and (3) a modular software to seamlessly integrate the entire process of ROM generation, computation, and verification.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)

Technical Objectives and Work Plan

The overall project objective is to develop a software framework and rigorous ROM algorithms to automatically generate and compute the ASE ROMs for control law design. The proposed effort will establish the proof-of-concept of applying nonlinear parameter-varying (PV) ROM techniques to analysis of aerostructural sensing and control. Specific Phase I objectives are: (1) develop a nonlinear PV aerodynamic ROM based on a hybrid methodology to enable ROM applicability in the entire flight envelope; (2) develop PV structural ROM engine for accurate prediction of mode changes associated with varying mass, properties, and model tuning applications; (3) integrate aerodynamic ROM, structural ROM, sensors, actuators, and controllers for integrated, closed-loop ASE analysis; (4) construct a modular software framework enabling automated data exchange, ROM generation and computation, and verification; and (5) demonstrate the software by performing ASE case studies of NASA interest (e.g., Aerostructures Test Wing and X-56A MUTT) to establish the proof-of-principle of the technology. Phase II effort will focus on: (1) algorithm improvement in terms of execution efficiency, reliability, automated parameter selection; (2) software environment enhancement (such as direct interface to NASA-relevant simulation and design tools and fully automated ROM process); and (3) extensive technology demonstration in complex scenarios.



NASA Applications

The proposed technology will provide a fast, accurate aeroservoelastic analysis tool with broad NASA applications, including: (1) performing computationally efficient analysis for optimal design of aerospace vehicles; (2) developing advanced, reliable aeroservoelastic control strategies (such as controlled maneuver and aeroelastic instability control, e.g., buffet, flutter, buzz, and control reversal); and (3) arranging test procedures for rational use of instruments and facilities.

Non-NASA Applications

The non-NASA applications will focus on aerospace, aircraft, and watercraft engineering sectors involving fluid-structure-control interaction, including Air Force, Missile Defense, Navy, business aircraft, automobile, and power industry, etc. It can be used to (1) perform fault diagnostics and optimized design and (2) develop strategies for on-line process control.

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NON-PROPRIETARY DATA